Brohm Lake Phytoplankton Summary Report 2021-2022

Overview

Samples were collected from one site on Brohm Lake during 2021 and 2022 (Figure 1; Table 1). Algae were identified to the taxonomic level genus and grouped into broad alga types for analysis.

Table 1: Sample sites and dates sampled in 2021 and 2022

Sample Site (EMS#)	Dates
BROHM LAKE; MIDLAKE (1132490)	2021-04-01
	2021-08-31
	2022-03-29
	2022-08-17
	Total= 4 samples

Figure 1: Aerial view of Brohm Lake

Algal counts in the spring were lower than the summer (Figure 2). Diatom numbers were low in all samples but demonstrated a small rise in density in both summer samples; *Aulacoseira* and *Ulnaria* were the dominant genera.

Diatoms are integral to aquatic food webs because they are the foundation of the food web (jrobyn, 2019). Colony forming diatoms such as *Aulacoseira* can avoid grazing pressures by developing into large colonies, reducing their availability for zooplankton and microscopic invertebrates (Baker, 2012).

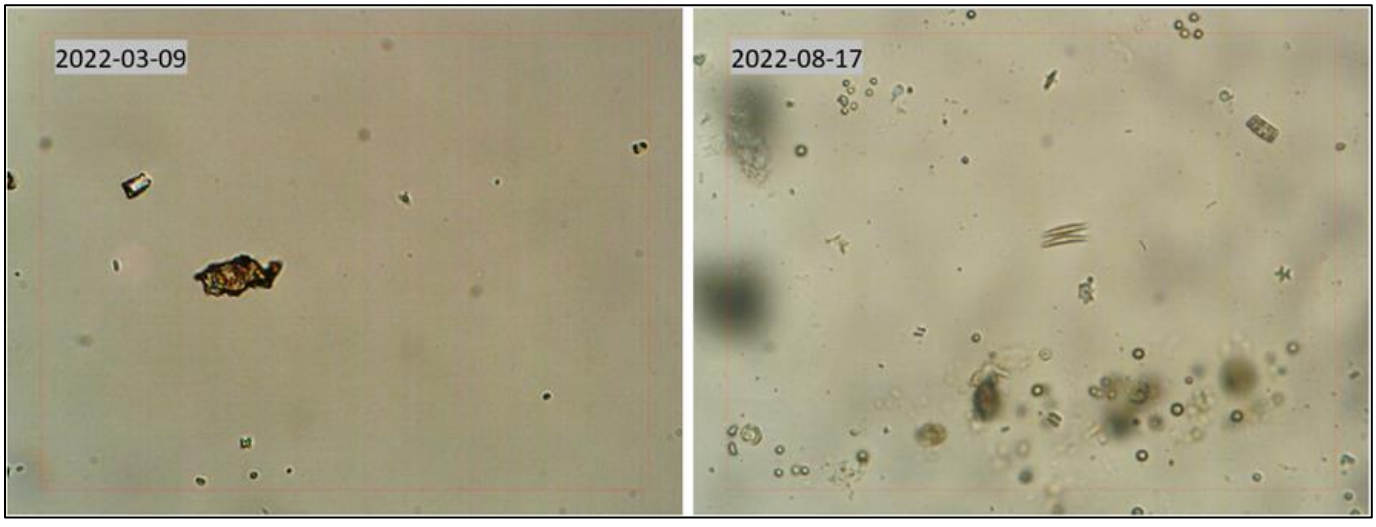

Figure 2: Typical algae density in the spring (Left) vs. summer (right)

Overview (continued)

All sites included moderate levels of micro-flagellates, specifically *Chrysococcus*, *Rhodomonas lacustris* and *Chrysochomulina* (Figure 3).

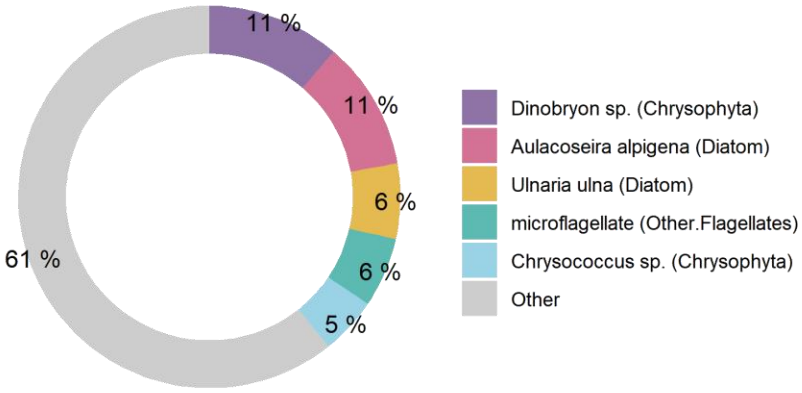

Figure 3: Dominant organisms from Brohm Lake; Midlake (1132490) as percent of total biovolume

Chrysophyta taxa are advantageous and disadvantageous in freshwater systems, depending on their context. Some Chrysophytes are known to produce odor chemicals described as fishy, while others eat bacteria and reduce negative odor compounds (Wehr et al., 2015).

One sample contained elevated densities of Chrysophyta (genus *Dinobryon;* Figure 3*;* Figure 4). *Dinobryon* blooms are associated with unpleasant fishy odors, and one species of *Dinobryon* is linked with toxins that can affect fish vitality (Cantrell & Long, 2013; Conrad, 2013). Sample collected on 2022-08-17 contained a small bloom of Synurophytes (genus *Synura*). When densities are high, *Synura* species cause water pigmentation and unpleasant odors through the production of secondary metabolites (Jo et al., 2016).

Figure 4: Dinobryon loricas (yellow arrows), EMS Site#1132490 collected on 2021-08-31

Algae – why should we care?

Algae blooms are becoming more frequent and severe worldwide due to excessive nutrient loading and warming summer lake temperatures. Diatom blooms can cause filter clogging, and odor issues.

Intense cyanobacteria blooms can threaten human safety and aquatic health through their toxicity. Illness related to cyanotoxins can include: liver, kidney, and nerve cell damage, cancer, skin and gut irritation, and neurological issues. Cyanotoxins, including microcystins, are now known to accumulate in the food chain (Lance et al. 2014). Fish from lakes with heavy cyanobacteria blooms can have higher toxin concentrations than the lake water (Greer et al. 2021) and consuming them can increase the risk of liver disease (Zhao et al., 2020).

Cyanobacterial Presence

Summer samples demonstrated high concentrations of cyanobacteria. Dominant genera included *Pseudoanabaena*, *Microcystis*, and *Chroococcus*. (Figure 5).

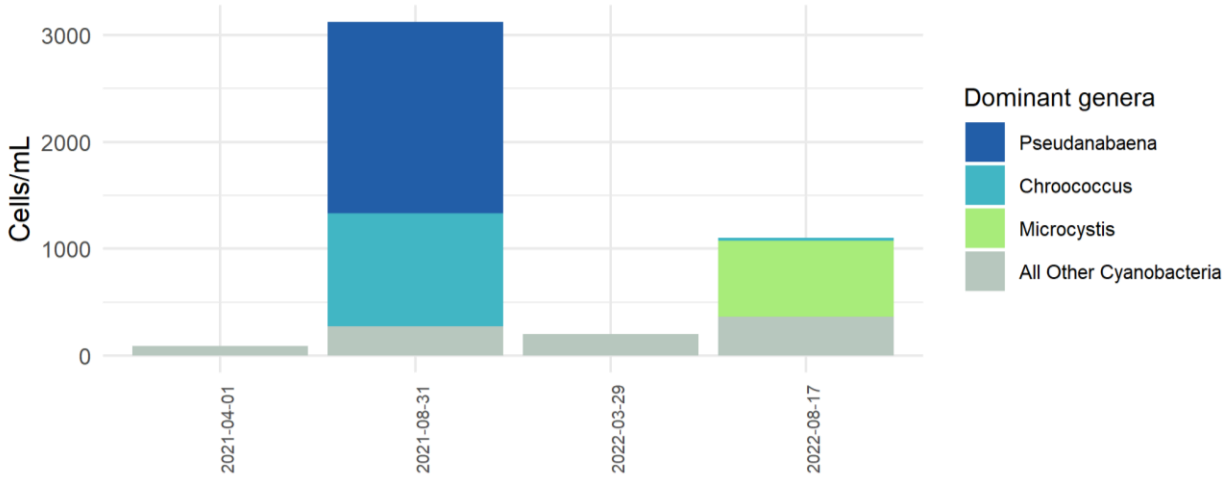

Figure 5: cell abundance for dominant cyanobacteria genera on Brohm Lake

Pseudanabaena is associated with toxins and odor compounds. *Microcystis* is a well understood and predominantly toxic genus of cyanobacteria. *Microcystis* blooms also pose aesthetic threats to water systems because the granular green-hued particles accumulate near shore and resemble a thick green paint (EPA, 2022). *Chroococcus* identified in summer samples is associated with several cyanotoxins which represent risks to public health (Table 2). Illness related to cyanotoxins can include: liver, kidney, and nerve cell damage, cancer, skin and gut irritation, and neurological issues (Lance et al., 2014).

Table 2: Dominant genera of cyanobacteria on Brohm Lake and their associated toxins

Genus	Maximum Abundance* (cells/mL)	Toxins Produced
Pseudanabaena	1791	Lyngbyatoxin LYN, Lipopolysaccharide LPS, Microcystin MC, Anatoxins (-a) ATX, BMAA, Taste and Odor
Chroococcus	1044	Microcystin MC, BMAA
Microcystis	710	Lyngbyatoxin LYN, Lipopolysaccharide LPS, Microcystin MC, Nodularins NOD, Anatoxins (-a) ATX, BMAA, Cyanopeptolins CPL, Anabaenopeptins APT

Note: * = counted in samples

Cyanobacterial Presence (Continued)

Dominant species of cyanobacteria identified in Brohm Lake are capable of producing cyanotoxins (Table 2).

Brohm Lake displayed cyanobacteria levels in the negligible-low risk category, with a mean cyanobacteria abundance of 1,131 cells/mL (Figure 6). Figure 6 exhibits the range of cyanobacterial abundance observed in Brohm Lake compared to alert levels defined by several authorities including the WHO and the EPA.

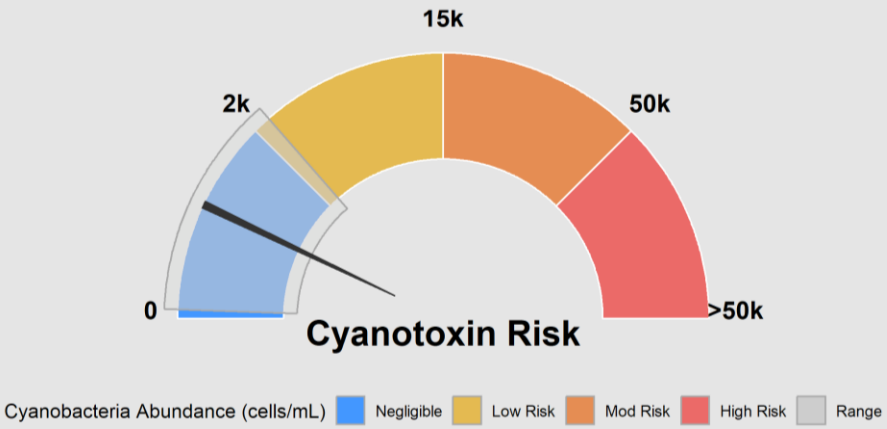

Figure 6: Cyanotoxin risk posed by cyanobacteria blooms in Brohm Lake

Cyanobacteria frequently dominate algal communities in total cell count, but because of their small cell size their biovolume is usually low relative to other types of algae. This is highlighted in Figure 7 where a single *Dinoflagellate* cell is an equivalent size to approximately 100 cyanobacteria cells.

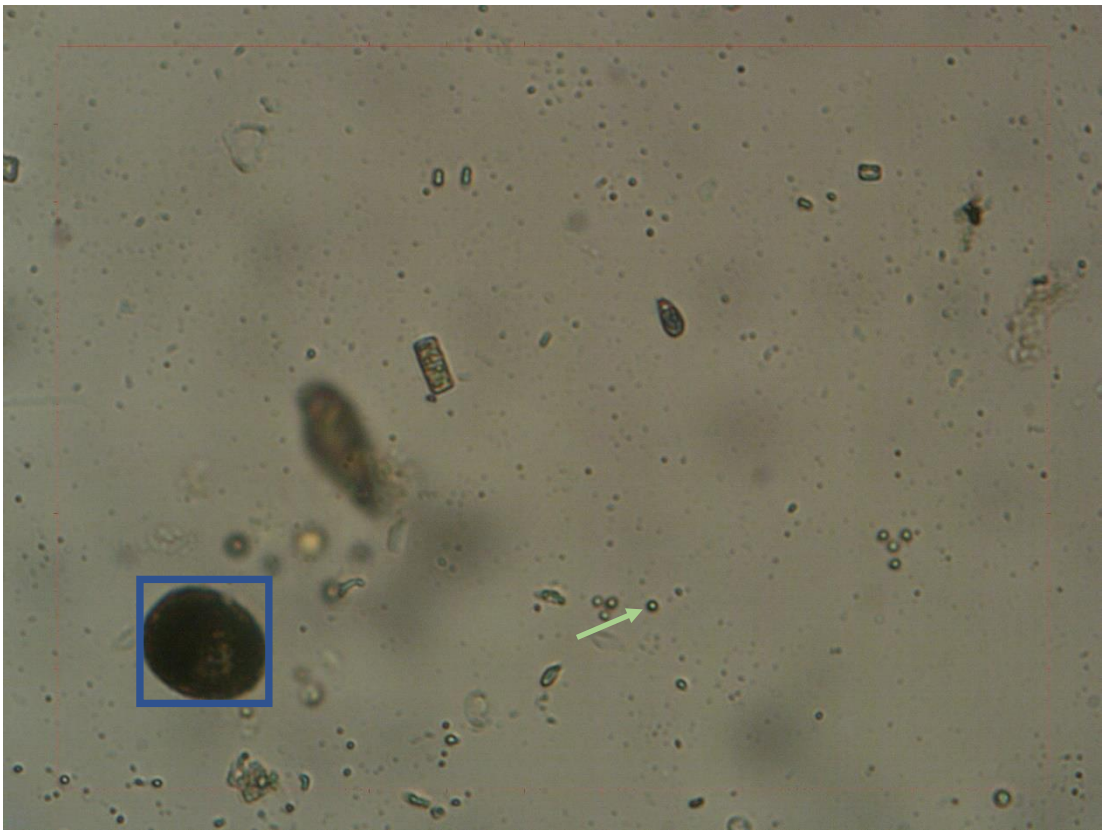

Figure 7: Size comparison of a Dinoflagellate cell (blue box) to an Anacystis cell (green arrow)

Species Composition

Algae samples were identified to the genus level and grouped into broad alga types for analysis. The figures below display total cell counts for each broad algae group alongside their biovolume. The difference between Figure 8 (cell abundance) and Figure 9 (biovolume) illuminates the difference between cell abundance and biovolume.

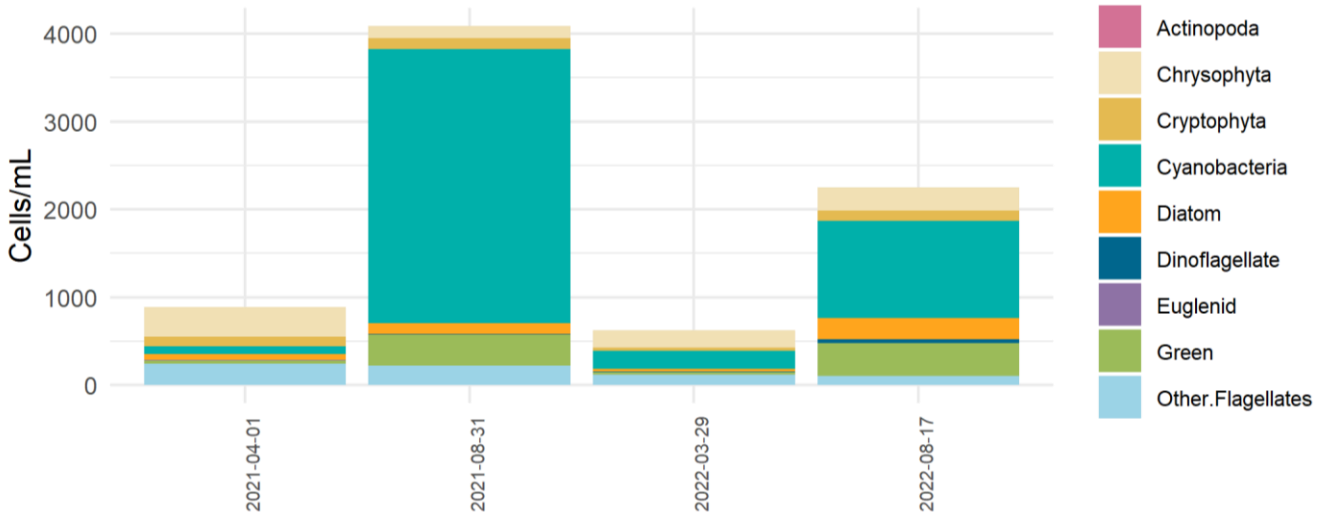

Figure 8: Cell abundance of high-level taxa groups on Brohm Lake

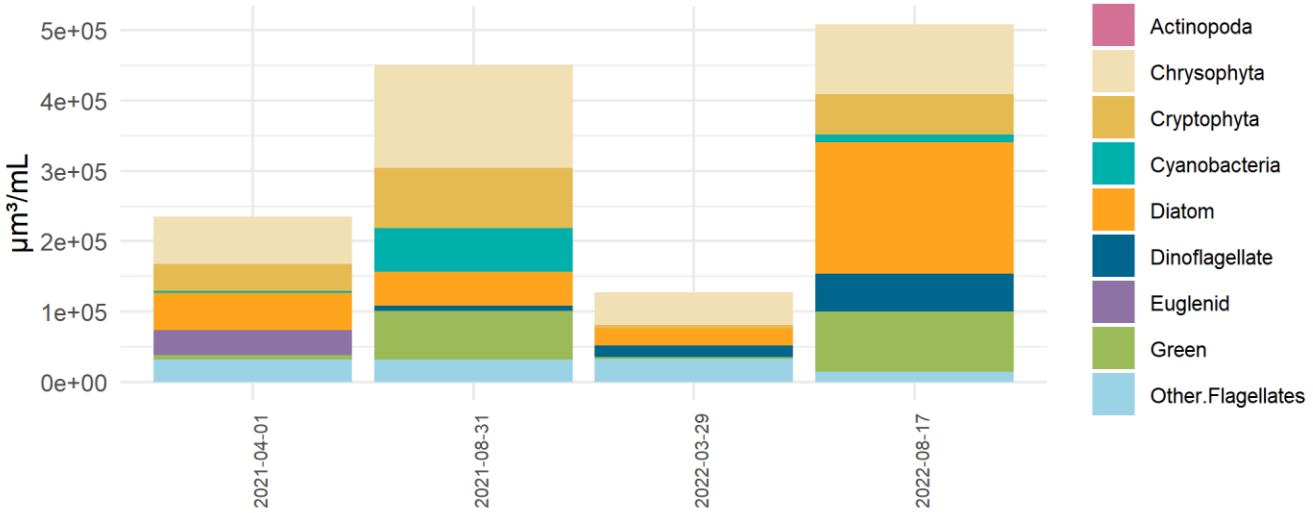

Figure 9: Biovolume of high-level taxa groups on Brohm Lake

References

Baker, A. L. et al. (2012). *Phycokey -- an image based key to Algae (PS Protista), Cyanobacteria, and other aquatic objects.* University of New Hampshire Center for Freshwater Biology. http://cfb.unh.edu/phycokey/phycokey.htm

Cantrell, R., & Long, B. (2013). *Dinobryon*. PBWorks. http://ohapbio12.pbworks.com/w/page/51731561/Dinobryon

Conrad, J. (2013). *DINOBRYON, a Golden Alga*. Jim Conrad's Naturalist Newsletter. https://www.backyardnature.net/n/x/dinobryo.htm

EPA. (2022, September). *Learn about Cyanobacteria and Cyanotoxins*. United States Environmental Protection Agency.

Jo, B. Y., Kim, J. I., Škaloud, P., Siver, P. A., & Shin, W. (2016). Multigene phylogeny of Synura (Synurophyceae) and descriptions of four new species based on morphological and DNA evidence. *European Journal of Phycology*, *51*(4), 413–430. https://doi.org/10.1080/09670262.2016.1201700

jrobyn. (2019). *How Diatoms Benefit a Body of Water - BioNova®*. BioNova. https://bionovanaturalpools.com/how-diatoms-benefit-a-body-of-water/

Lance, E., Petit, A., Sanchez, W., Paty, C., Gérard, C., & Bormans, M. (2014). Evidence of trophic transfer of microcystins from the gastropod Lymnaea stagnalis to the fish Gasterosteus aculeatus. *Harmful Algae*, *31*, 9–17. https://doi.org/10.1016/J.HAL.2013.09.006

Wehr, J. D., Sheath, R. G., & Kociolek, P. (2015). *Freshwater Algae of North America* (Second). Elsevier Inc.

Zhao, Y., Yan, Y., Xie, L., Wang, L., He, Y., Wan, X., & Xue, Q. (2020). Long-term environmental exposure to microcystins increases the risk of nonalcoholic fatty liver disease in humans: A combined fisher-based investigation and murine model study. *Environment International*, *138*, 105648. https://doi.org/10.1016/J.ENVINT.2020.105648

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Appendix

Additional figures and raw data are listed below:

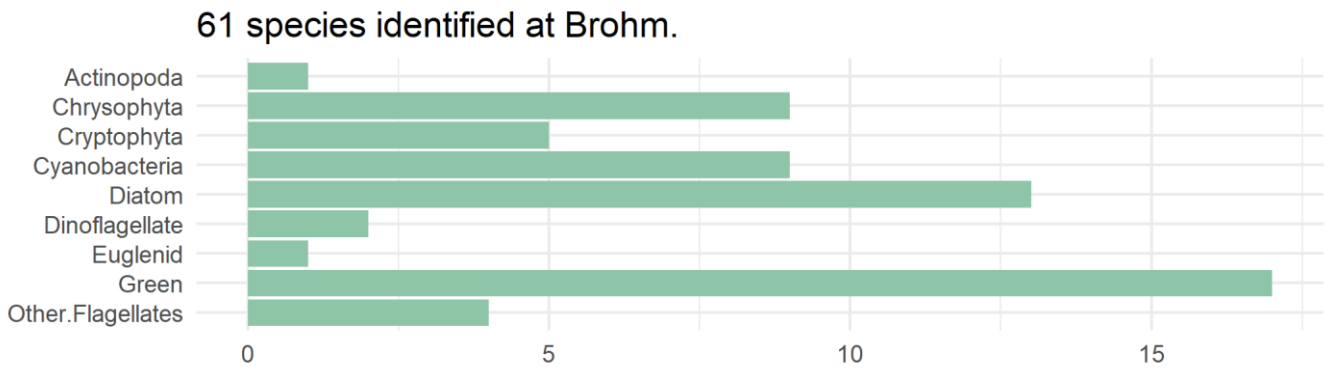

Figure 10: Identified species sorted into categories of higher-level taxa

EMS ID: 1132490	**Total Abundance (cells/mL):**	**891**		
Collection Date: 2021-04-01	**Total Biovolume (µm³/mL):**	**245764**		
Report.Name	**Abundance (cells/mL)**	**Biovolume (µm³/mL)**	**High.Level.Taxa**	**ITIS Genus Number**
Dinobryon sp.	8	12016	Chrysophyta	1515
Ochromonas sp.	65	13914	Chrysophyta	1455
Chrysochromulina sp.	152	5846	Chrysophyta	2160
Chroomonas sp.	23	5230	Chrysophyta	10613
Chrysococcus sp.	91	30214	Chrysophyta	1751
Dinobryopsis sp.	23	6178	Chrysophyta	1557
Cryptomonas sp.	15	27781	Cryptophyta	10635
Rhodomonas lacustris	95	10315	Cryptophyta	10663
Aphanizomenon flos-aquae	19	3164	Cyanobacteria	1191
Anacystis sp.	72	137	Cyanobacteria	609
Achnanthidium minutissimum	19	3604	Diatom	590864
Aulacoseira distans var. nivalis	27	5429	Diatom	590863
Nitzschia sp.	8	734	Diatom	5070
Ulnaria ulna	8	42038	Diatom	970000
Trachelomonas scabra	11	36493	Euglenid	9690
Tetraedron incus	27	3789	Green	5661
Scenedesmus sp.	8	1867	Green	6104
microflagellate	220	37015	Other.Flagellates	

Figure 11: Raw data from 2021-04-01 EMS site 1132490

EMS ID: 1132490	Total Abundance (cells/mL):	4090		
Collection Date: 2021-08-31	Total Biovolume (µm³/mL):	460284		
Report.Name	**Abundance (cells/mL)**	**Biovolume (µm³/mL)**	**High.Level.Taxa**	**ITIS Genus Number**
Dinobryon sp.	80	120160	Chrysophyta	1515
Mallomonas sp.	4	12097	Chrysophyta	1598
Chrysochromulina sp.	15	577	Chrysophyta	2160
Chrysococcus sp.	42	13945	Chrysophyta	1751
Dinobryopsis sp.	4	1074	Chrysophyta	1557
Cryptomonas sp.	15	27781	Cryptophyta	10635
Cryptomonas ovata	8	17407	Cryptophyta	10635
Cryptomonas marssonii	15	30628	Cryptophyta	10635
Rhodomonas lacustris	87	9446	Cryptophyta	10663
Anacystis sp.	106	202	Cyanobacteria	609
Chroococcus minutus	1044	39416	Cyanobacteria	654
Chroococcus dispersus	15	212	Cyanobacteria	654
Pseudanabaena sp.	1791	19956	Cyanobacteria	1175
Planktolyngbya sp.	15	186	Cyanobacteria	
Snowella lacustris	152	1667	Cyanobacteria	
Achnanthidium minutissimum	4	759	Diatom	590864
Aulacoseira alpigena	61	33080	Diatom	590863
Cyclotella sp.	42	11150	Diatom	2439
Cymbella sp.	4	6773	Diatom	4795
Platessa conspicua	11	706	Diatom	
Peridinium inconspicuum	4	7326	Dinoflagellate	10212
Crucigenia fenestrata	53	12157	Green	6225
Crucigenia tetrapedia	61	7472	Green	6225
Elakatothrix gelatinosa	83	14660	Green	9412
Oocystis sp.	15	283	Green	5827
Schroederia setigera	4	1018	Green	
Tetraedron caudatum	30	4210	Green	5661
Tetraedron lunula	15	2105	Green	5661
Tetraedron minimum	15	1845	Green	5661
Spondylosium planum	30	14043	Green	8468
Scenedesmus sp.	34	7935	Green	6104
Scenedesmus serratus	15	3501	Green	6104
microflagellate	212	35669	Other.Flagellates	
Kephyrion ampulla	4	838	Other.Flagellates	1764

Figure 12: Raw data from 2021-08-31 EMS site 1132490

EMS ID: 1132490	Total Abundance (cells/mL):	625		
Collection Date: 2022-03	Total Biovolume (µm³/mL):	127269		
Report.Name	**Abundance (cells/mL)**	**Biovolume (µm³/mL)**	**High.Level.Taxa**	**ITIS Genus Number**
Dinobryopsis sp.	15	4029	Chrysophyta	1557
Chrysochromulina sp.	102	3923	Chrysophyta	2160
Chroomonas sp.	19	4320	Chrysophyta	10613
Chrysococcus sp.	53	17597	Chrysophyta	1751
Dinobryon sp.	11	16522	Chrysophyta	1515
Rhodomonas lacustris	38	4126	Cryptophyta	10663
Anacystis sp.	205	390	Cyanobacteria	609
Achnanthidium sp.	4	759	Diatom	590864
UID centric diatom	4	673	Diatom	
Melosira sp.	4	4562	Diatom	2290
Nitzschia sp.	4	367	Diatom	5070
Aulacoseira sp.	11	18102	Diatom	590863
Glenodinium sp.	8	15984	Dinoflagellate	10174
Tetraedron incus	11	1544	Green	5661
Crucigenia tetrapedia	15	1838	Green	6225
microflagellates	121	32533	Other.Flagellates	

Figure 13: Raw data from 2022-03-29 EMS site 1132490

EMS ID: 1132490	Total Abundance (cells/mL):	2251		
Collection Date: 2022-08-17	Total Biovolume (µm³/mL):	513953		
Report.Name	**Abundance (cells/mL)**	**Biovolume (µm³/mL)**	**High.Level.Taxa**	**ITIS Genus Number**
Actinophryida	4	673	Actinopoda	
Chrysococcus sp.	8	2656	Chrysophyta	1751
Chrysochromulina sp.	42	1615	Chrysophyta	2160
Dinobryon spp.	30	47594	Chrysophyta	1515
Mallomonas sp.	4	12097	Chrysophyta	1598
Ochromonas sp.	15	3211	Chrysophyta	1455
Dinobryopsis sp.	23	6178	Chrysophyta	1557
Synura sp.	140	25143	Chrysophyta	1655
Cryptomonas sp.	4	7408	Cryptophyta	10635
Cryptomonas erosa	23	40753	Cryptophyta	10635
Rhodomonas lacustris	91	9881	Cryptophyta	10663
Aphanizomenon flos-aquae	11	1832	Cyanobacteria	1191
Chroococcus sp.	30	1005	Cyanobacteria	654
Gloeocapsa punctata	353	1479	Cyanobacteria	682
Microcystis sp.	710	5809	Cyanobacteria	747
Asterionella formosa	4	2785	Diatom	3116
Aulacoseira alpigena	212	114965	Diatom	590863
Epithemia adnata	8	26389	Diatom	5005
Platessa conspicua	8	377	Diatom	
Ulnaria ulna	8	42038	Diatom	970000
Parvodinium sp.	23	12681	Dinoflagellate	
Glenodinium sp.	15	29971	Dinoflagellate	10174
Peridinium inconspicuum	8	14652	Dinoflagellate	10212
Crucigenia fenestrata	38	8716	Green	6225
Crucigenia tetrapedia	87	10658	Green	6225
Elakatothrix sp.	8	1536	Green	9412
Monoraphidium minutum	38	25175	Green	5990
Oocystis sp.	11	207	Green	5827
Tetraedron minimum	27	3321	Green	5661
Tetraedron caudatum	11	1544	Green	5661
Tetraedron incus	57	7999	Green	5661
Quadrigula closteroides	19	5558	Green	5938
Didymocystis bicellularis	68	18319	Green	55858
Scenedesmus aculeolatus	11	2567	Green	6104
microflagellate	102	17161	Other.Flagellates	

Figure 14: Raw data from 2022-08-17 EMS site 1132490